Payments for Agrobiodiversity Conservation Services: An Overview of Latin American experiences, Lessons Learned and Upscaling Challenges

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Highlights

- Innovative application of PES to conservation of agrobiodiversity
- Overview of nine schemes in four countries, covering 130 threatened crop varieties
- Conservation costs are modest
- A range of lessons and upscaling challenges are identified

Abstract

Many developing countries face a major challenge today: how to safeguard the biodiversity maintained in the fields of the rural poor - which constitute a national and global public good - whilst meeting those same people's development needs and rights? A solution to this dilemma has thus been sought in adapting the design and implementation of Payments for Ecosystem Services (PES) concepts to the conservation of agrobiodiversity.

Here we review the application of nine such Payments for Agrobiodiversity Conservation (PACS) schemes that have been applied to date in four Latin American countries over the period 2010-2018. These covered 130 threatened varieties across a number of major food crops, and involved over 100 farming communities and 1,100 farmers (45% of which were women). Conservation service offers were received through a competitive tender mechanism Average bid offers revealed high heterogeneity, varying between US$675/ha. to 10 times as much.

In relation to issues identified as key to PES, such as spatial targeting, differentiated payments and conditionality, the underlying design of the PACS schemes may be considered solid. PACS-related prioritisation processes allow for the *a priori* identification of sites with high ecosystem service densities and high threat levels. The use of competitive tenders permits accounting for cost heterogeneity in the provision of conservation services and for payments to be differentiated. Conditionality is strong.

In terms of implementation, a "back of the envelope" calculation based on the results of the competitive tenders suggests that conservation costs are modest. For a priority conservation portfolio of 100 varieties (which may be from different crops) each with a target area of five hectares, costs would amount to just under USD860,000 over twenty years or USD70,000 p.a. at a 5% discount rate. The small-scale and one-off nature of the interventions realised to date, along with threatened crop variety seed availability constraints, have however meant that environmental effectiveness has been incomplete in the short-term (increased area cultivated with specific threatened varieties, but still below the "not at risk" threshold). The establishment of systematic monitoring systems is required to determine longer-term impacts and inform more regular PACS interventions within a dynamically evolving systems context.

Keywords

Payments for Ecosystem Services, agrobiodiversity, crop genetic resources, on farm conservation, incentive mechanisms, conservation costs

1. Introduction

Payments for ecosystem services (PES) have been widely applied as incentive mechanisms to motivate natural resource conservation where important public good ecosystem service values exist, such as in the case of forests, water, wild biodiversity and landscape aesthetics (see Wunder et al 2018; Salzman et al 2018; and Börner et al., 2017 for recent overviews). Expanding over recent decades, there are now over 550 active PES programmes world-wide, with estimated transactions of US$36–42 billion p.a. (Salzman et al., 2018). However, relatively few of these are focussed on biodiversity conservation, yet alone agrobiodiversity[1] (ABD). For example, out of the 40 PES cases that Grima et al. (2016) identified for performance analysis purposes, half were focussed on water, 28% involved bundled ecosystem services, 12% landscape protection, 8% maintaining carbon stocks and just 2% biodiversity protection.

While some of the largest public biodiversity PES programs are the agri-environment payment programs in the United States and Europe (Scherr et al., 2007), such applications in agriculture have been largely focussed on promoting more (wild) biodiversity- and ecosystem-friendly practices (Kleijn and Sutherland, 2003; and Lipper et al., 2009). With some rare exceptions, such as the EU support payments for threatened livestock breeds under Regulations 1257/99 and 1750/99, the need to intervene to ensure that agricultural biodiversity *per se* is maintained has received much less attention (Narloch et al., 2011a; Pascual et al., 2103). This is despite the fact that high public good ecosystem service values (e.g. maintaining landscape resilience, food security and climate change adaptation potential) are associated with its *in situ* maintenance; while an unprecedented and irreversible loss of ABD continues unabated at ecosystem, species and genetic levels throughout the world, with threats to diversity getting stronger (among others, FAO 2010, 2015 and 2019).

With a view to supporting implementation of a range of international agreements, sustainable development goals[2] and national legislation, Bioversity International (now the Bioversity-CIAT Alliance) and its partners have been leading the conceptual development and testing in a number of countries of "payments for agrobiodiversity conservation services" (PACS). PACS may be understood as a sub-category of agrobiodiversity-related PES that focuses on socially valuable and threatened local plant and animal genetic resources. Small-scale PACS schemes have been implemented for quinoa (Narloch et al. 2011a&b) in Peru and Bolivia, amaranth (Drucker et al., 2018) and potato in Peru, maize in Ecuador, and beans and maize in Guatemala (Padulosi and Drucker, 2018). Hypothetical applications have also been undertaken in India (Krishna et al., 2013) and Nepal (Pallante et al., 2016) for minor millets, and Zambia for crop wild relatives (Wainwright et al., 2019). This has led to the emergence of a body of work related to the application of the concepts of PES to the conservation of ABD per se. A range of related conservation and use management topics that contribute to the broader PES literature have also been explored, such as: addressing distributional/social equity issues and accounting for local concepts of fairness (Narloch et al., 2012 and 2017; Midler et al., 2015); prioritisation (Samuel et al., 2013); conservation target setting, monitoring (Dulloo et al., 2016); facilitating value chain development (Pallante et al., 2016; Drucker and Appels, 2016); and identifying potential conservation service purchasers (Drucker et al., 2013). PACS may also be seen as an

[1] Biodiversity for food and agriculture or "agrobiodiversity" is a subcategory of biodiversity that corresponds to "the variety and variability of animals, plants and micro-organisms at the genetic, species and ecosystem levels that sustain the ecosystem structures, functions and processes in and around production systems, and that provide food and non-food agricultural products" (FAO, 2013 in FAO, 2019).

[2] Such as the Convention on Biological Diversity's Aichi Targets 3 (Incentives) and 13 (Conservation of Diversity); Sustainable Development Goal 2 (Zero Hunger, including sustainable agriculture, food security, nutrition and the conservation of diversity) and the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) [Farmer's Rights and the Fair & Equitable Sharing of Benefits].

instrument for the *de facto* implementation of Farmers' Rights (Clancy and Vernooy, 2014), by facilitating the sharing of benefits in a cost-effective manner with high levels of social justice and without having to depend on/wait for commercial product development.

This paper provides a review of the main results and lessons learned from the experience gathered between 2010-2018 in Latin America (Peru, Bolivia, Ecuador and Guatemala). Although globally applicable, the Americas has provided a particularly useful testing ground for the application of PES in the context of ABD conservation and use. It is a continent with high ecosystem service density, with seven countries classified as being megadiverse (UN-WCMC, 2014) and the presence of millions of traditional farmers that maintain native agrobiodiversity on their farms. Furthermore, countries such as Peru, with well-developed regulatory frameworks in place, have been particularly keen on the adoption of PACS as a means of actively implementing national commitments under, *inter alia*, Peruvian Laws 26821 (Conservation and Sustainable Use) and 30215 (Mechanisms for Payments for Ecosystem Services).

With there now being results available across a range of crops and countries, and with Peru now implementing their first multi-year PACS schemes as part of a three year Global Environmental Facility "Sustainable Management of Agrobiodiversity" project across four regions, this paper aims to identify some timely key messages for future applications in Latin America and elsewhere.

2. PACS Background

The conceptual framework that connects the problem of loss of ABD and human wellbeing has been described in detail elsewhere (e.g. Pascual and Perrings, 2007; Drucker and Rodriguez, 2007; Narloch et al., 2011a; Pascual et al 2013). It draws mostly on an economic perspective of the problem of the replacement of a valuable diverse existing pool of local plant and animal genetic resources with a smaller range of specialized improved ones - with such replacement taking place as part of a process of development through agricultural intensification that benefits individual actors at the expense of society at large. The existence of significant non-market and/or public good values of plant and animal genetic resources, an overestimation of the performance of *improved* plant and animal genetic resources under less than ideal production system conditions and important intervention failures (e.g. subsidies that bias against traditional production systems) provide a strong justification for policy intervention. Such interventions would ensure that farmers undertaking de facto conservation through the maintenance of socially desirable levels of plant and animal genetic resources would be recognised and compensated for the national and global contributions they provide.

PACS, like PES schemes more broadly, are based on a voluntary transaction of a well-defined service between at least one service provider and beneficiary, when the provider secures service provision (conditionality) [Wunder 2006 and 2007]. PACS creates the opportunity for farmers to no longer only sell an agricultural commodity, but also be rewarded for the provision of a conservation service for the good of society. Under PACS, farmers are rewarded for growing threatened genetic resources of high public good value; incentives are offered at community level and involve landscape-wide competitive tenders (*spatial targeting concept*). Groups define their participation conditions (i.e. which priority species/varieties to cultivate from a given portfolio, kind and level of reward needed, which farmers participate). *Efficiency and social equity criteria* (including gender) are then used by the project to select communities with the most attractive bids (*payment differentiation concept*) ideally up to the point that conservation targets are attained but in practice more commonly to the point that the conservation budget is fully expended. Conservation targets are based on a combination of variety areas (related to maintaining diversity, geneflow and evolutionary processes), as well as in terms of numbers of farmers (related to traditional knowledge and cultural practices) and communities (related to spatial distribution/targeting and landscape resilience).

Once communities have been contracted and seed distributed, compliance verification/monitoring (*conditionality concept, effectiveness criteria*) visits are carried out at certain key moments during the agricultural calendar (e.g. at the time of sowing, plant emergence, flowering, harvesting). This also provides opportunities for extension services to provide technical assistance and training (e.g. in quality seed selection), as well as undertake additional data collection. At harvest, the project keeps a small percentage (generally 2-5%) as seed for distribution to other farmers in following years. The in-kind rewards – for example, agricultural inputs, building and school materials - are subsequently handed-over at reward ceremonies. Such ceremonies have also provided opportunities for high visibility events, with the participation of vice ministers, and heads of national and local institutions, thereby supporting the mainstreaming of agrobiodiversity into national and regional (state) conservation policies and strategies (with regard to the Peru [Puno II] ceremony see Drucker, 2016). Figure 1 provides an illustration of the overall PACS process.

3. Method

With a view to identifying the range of potential PACS scheme applications to be reviewed, a literature search was carried out on Google Scholar and ISI Web of Knowledge. Publications associated with agrobiodiversity-related PES remain extremely limited. Bioversity International-associated journal publications, conference presentations, briefs, blogs, webpages and unpublished project reports continue to be the main source of materials related to PACS and these materials were collated for review (see sources cited in Table 1). The selected case studies represent all of the Latin American experiences from 2010 initial piloting to 2018. Case studies from India and Nepal were considered beyond the scope of this review as they did not include actual implementation data, while that of Zambia focussed on crop wild relatives rather than landraces.

The selected PACS scheme project sites are all located in some of the world's most biodiverse countries and in areas specifically associated with a high diversity of crops and crop varieties of importance for food security and the livelihoods of the poor (see Figure 2). These areas are also located within globally important centres of origin for, *inter alia*, quinoa, amaranth, potato, maize, beans and cassava (all of which have been subject to a PACS intervention other than the latter). Such areas are associated with a wide cultural and ethnic diversity, as well as high levels of traditional knowledge. However, farm sizes are small and vulnerability to climate change high. Poverty rates (>85% in some areas) and chronic malnutrition are high, with women being the worst affected.

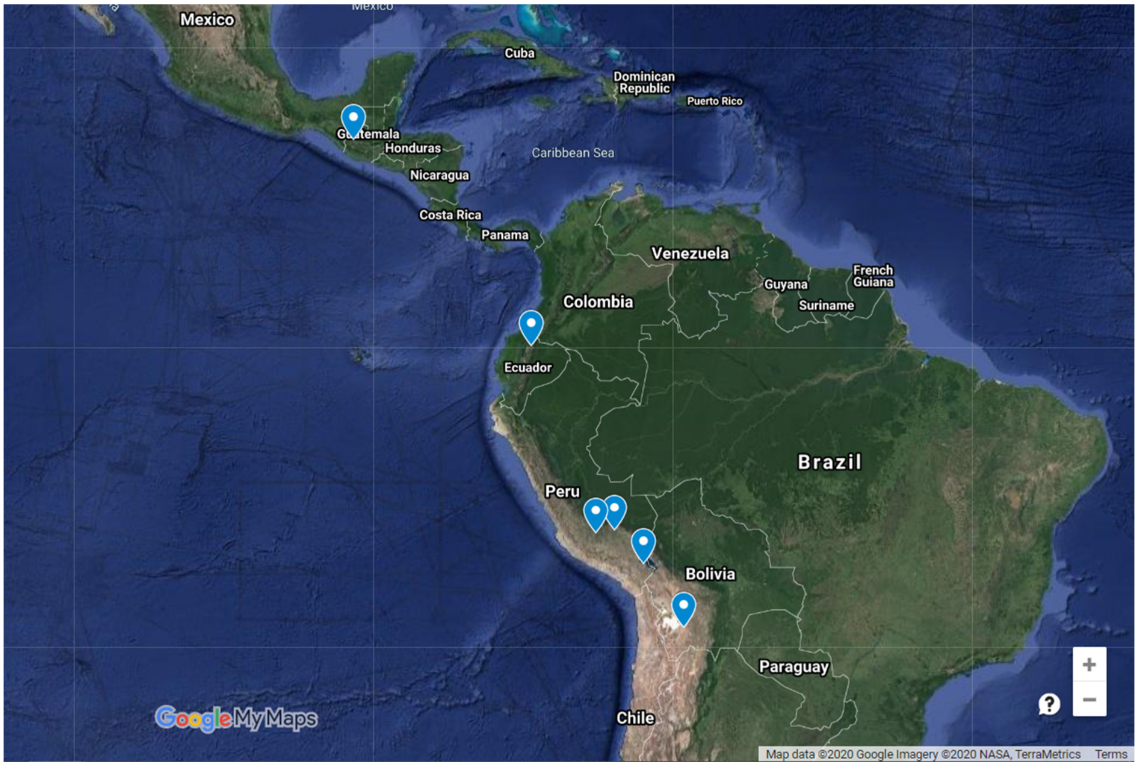

Figure 2: Map of PACS 2010-2018 locations in Latin America

Following prioritisation of the specific threatened crop varieties that are to be subjected to a PACS intervention (see below for further details), project sites within the above areas where such varieties used to be cultivated or continue to have a small presence were identified. In collaboration with national stakeholders (government extension agents, NGOs, university agricultural departments, etc.) communities within such project sites are notified about the existence of the PACS scheme, invited to participate in a training workshop and offered technical support for making a conservation service bid offer if they wish to do so. The sample population from which the tender results are drawn (through the application of a linear programming model, as per Wainwright et al, 2019) is thus self-selecting, at least within the proscribed project site/genetic resources catchment area. The same applies to the farmers who choose to participate within their community's group bid offer, given that all farmers within the community are eligible to participate.

All PACS schemes adhered to the generic approach described in the previous section. In terms of broader PES concepts, as identified by Wunder et al. (2018), strong conditionality (no group reward paid unless all members deliver the contracted conservation service) was applied, with regular compliance verification and monitoring visits taking place between planting and harvesting. All cases also involved the potential to account for spatial differentiation and social equity/distributive considerations, which along with the use of group-level rewards paid in-kind rather than in cash contribute to the innovative nature of these PES-type schemes.

The largest differences between the application of the different PACS schemes were in fact related to the prioritisation process informing site selection. Identification of the varieties to be subjected to the PACS interventions were identified through prioritisation exercises involving expert opinion including from genebank curators (Bolivia and Peru [Puno I]), the application of a Weitzman approach (Peru [Puno II]; Kost, 2016), as well as the 4 Cell Method (Ecuador and Guatemala; as per Sthapit et al., 2006). Method choice in practice was determined by data availability (e.g. existence and access to ex situ characterisation data in the case of Weitzman) and time/funding constraint considerations. In prioritising, a range of factors were considered, such as distinctiveness, threat status, importance for climate change adaption, food security and livelihoods.

4. Results

As can be seen in Table 1, PACS have been applied to date in four Latin American countries, covering five commodity crops (quinoa, amaranth, potato, maize and beans) plus a number of others and leading to interventions on over 130 threatened crop varieties. While not all invited communities ultimately chose to do so, 156 communities involving over 1,600 farmers and 164 hectares submitted conservation service bid offers.

Reward payments were funded through specific projects, as well as more recently with in-kind and cash support from regional governments and the private sector, respectively. As all the applications to date have been small-scale, with total payment budgets being just under USD7,000 on average, only about 70% of these offers (109 communities and 1,114 farmers) and just under half (47%) of the offered land area (77 hectares) could be selected to participate in the conservation activities. However, there is a large variation between the PACS schemes, with Peru, Apurimac, and Ecuador I&II taking a strong egalitarian approach and selecting 100% of the bid offers; while the Peru (Puno II) quinoa scheme was only able to select about 20% of the offers made with the budget available.

On average, just under half of the selected farmers were female (45.5%), although this also varied significantly between schemes from a low of 5% in Chiquimula, Guatemala to 93% under the Ecuador I PACS scheme. Post-project intervention satisfaction has generally been high amongst farmers (for details of assessments of the 2010/11 experiences in Bolivia and Peru, including farmer quotes, see Drucker et al., 2015 pp.25-26)

Table 1: Overview of Latin American Payments for Agrobiodiversity Conservation Services Schemes Applications

Location	Crop	Number of varieties	Rewards Funding Available (USD)	Conservation Bid Offers Received (Number of Communities/ Farmers)	Conservation Bid Offers Selected (Number of Communities/ Farmers)	Number of hectares selected/offered	Percentage of Female Farmers in Selected Bid Offers	Range of Bid Offers ((USD/ha per year)	Average Cost/ha of Selected Bid Offers (USD per year)	Cost/farmer of Selected Bid Offers (USD per year)
1) Bolivia (Uyuni)[a] 2010/2011	Quinoa	5	4,000	12/N.A.	6/42	8.0/25.8	22%	120-3,571	500	95.24
2) Peru (Puno I)[a] 2010/2011	Quinoa	4	4,000	13/N.A	6/41	1.45/7.46	45%	2,272-10,573	2,759	97.56
3) Peru (Puno II) 2015/2016	Quinoa	5	4,200	30/370	6/45	11.82/63.07	64%	95-29,044	355	93.33
4) Peru (Cusco)[b] 2017/18	Amaranth	54**	9,100	25/416	16/223	3.08/12.01	40%	758 – 6,060	2,955	40.81
5) Peru (Apurimac) 2017/18	Potato	75	9,100	8/159	8/159*	11.56/11.56	28%	N.A.	787	57.23
6) Guatemala (Chiquimula)[c] 2017/2018	Beans	4 (6)[#]	5,000	7/216	7/150	4.73/7.23	5%	422-1,124	844	33.33
7) Guatemala (Huehuetenango) 2017/2018	Maize (and beans)	9 (11)[&]	6,650	7/102	6/90	5.29/5.82	33%	819-2,485	1,257	73.89
8) Ecuador (Cotacachi I) 2015/2016	Maize (plus other crops such as potato, sweet potato, mashua and beans)	9	13,300	32/237	32/237*	15.5/15.5	93%	467	858	56
9) Ecuador (Cotacachi II) 2016/2017	Maize (plus other crops as above as well as lentil, carrot and yam)	17[^]	7,100	22/127	22/127*	15.9/15.9	79%	467	447	56
	Total	**>128**		**156/>1,627**	**109/1,114**	**77.3/164.4**				
	Average		**6,939**				**45.5%**	**678 – 6,724**	**1,196**	**57**

N.A.: Data not available; *All offers selected and, in the case of Ecuador, offers were identical; ** number of accessions, not all of which are from distinct varieties. Consequently, have not been included in varietal total below, resulting in a sub-estimate; # Offers received for six varieties but seed available only for four; & Bid offers received for 11 varieties but offers selected covered only nine; ^Eight of which were the same as under Ecuador I.. Source: Drucker et al., 2017 and/or Bioversity project reports (unpublished), unless otherwise stated. [a] Narloch et al., 2011a&b and Drucker et al., 2015; [b] Drucker et al., 2018; [c] Padulosi and Drucker, 2018

5. Discussion

5.1 Differentiated payments and cost-effectiveness

The use of competitive tenders among potential PES conservation service providers is often seen as potentially complex and expensive to organize, although the evidence for this within PACS is limited (more on transaction costs below). Rather, the experience has been that, as predicted by theory, they are highly effective in revealing provider costs. The PACS schemes revealed a wide range of bid offers (USD 95 – 29,000/ha p.a.), with the average over the nine schemes varying between USD 678 – 6,724/ha. p.a.

The bid ranges allow conservation service supply curves to be constructed per variety in terms of area, as well as in terms of goals related to numbers of participating farmers and communities. For examples of the different PACS supply curves associated with Bolivia and Peru (Puno I) see Narloch et al. (2011b p.4). It is particularly interesting to note that farmers reveal very different preferences for different traditional varieties, as expressed through their bid offers. A range of different market (e.g. yield, ease of sale) and non-market values (e.g. taste, preparation time, cultural/ritual uses), as perceived by farmers, is likely to explain such differences. Elsewhere it has been shown that consumption values rather than production ones can play an important role in driving bid offers (e.g. Krishna et al. 2013). In some cases, the cost of in situ on farm conservation of a particularly expensive variety suggests that an alternative (i.e. not on farm) conservation strategy for that variety is needed.

The top end of such bid ranges (i.e. $29,000/ha.) clearly exceed any opportunity cost measures of production that might exist and may be considered as outliers. These bids may have resulted from inexperienced tender participants making uncompetitive bids (e.g. a tractor requested in exchange for the conservation offer of a very small land area) and others may simply not have been interested in non-commercial variety production. However, those at the lower end of the range are particularly interesting. They demonstrate that, given modest conservation goals, there may well be a sufficiently large pool of lower cost farmers (i.e. the motivated sellers key for upscaling, as per Salzman et al., 2018) at the bottom end of the supply curves who could be attracted to participate under upscaled projects that cover larger numbers of communities.

Overall, the existence of significant heterogeneity in farmer willingness to participate (except for those in Ecuador, where strong egalitarian principles would appear to apply) suggests that any additional costs or complexities associated with tender approaches may well be worth incurring. In any case, from an up-scaling perspective small-scale tenders of the type being realised could be used first as a research tool, to then guide the subsequent selection of proxies for price differentiation at larger scales of implementation, as noted by Wunder et al. (2018).

5.2 *Environmental Effectiveness*

Environmental effectiveness has been slower to achieve than originally anticipated not only by the small scale and limited duration (usually a single agricultural season) of the PACS interventions, but in many cases by seed availability as well.

With the exception of Peru (Puno II), which had the opportunity to select up to 63 hectares for conservation purposes, none of the PACS applications in Table 1 were sufficiently large to attract or have selected enough bids to reach an area conservation target of five hectares per variety. For example, under Peru (Puno I), the four varieties in question could only be conserved on 1.45 hectares in total. Similarly, under Guatemala [Huehuetenango] nine varieties could be conserved on only 5.3 hectares in total. Other varieties met a lower conservation target? of between 1-2 hectares (e.g. under Peru [Puno I] and Guatemala [Chiquimula]).

Even in the case of Peru (Puno II), reaching the conservation target for all five varieties would have required a budget of approximately US$19,100 (equivalent to US$750/ha) .Given that the budget available was only $4,200, this meant that less than 20% of the offers could be accepted, resulting in the Ccoito and Chulpi Real quinoa varieties conservation contracts falling just short of the target with 4.2-4.7 hectares and the others falling well short. However, in the following year, thanks to the intervention of Kai Pacha Foods (Wankel and Hethcote, 2017) – a motivated private sector buyer - the latter did reach the conservation target and has now been declared "not at risk" by the Ministry of the Environment.

In other cases, conservation targets could not be reached not because of limited budgets but rather as a result of insufficient seed availability. For example, only 250g per accession were available under the Peru (Amaranth) intervention. In Guatemala [Chiquimula] although bid offers were received for the San Jacinto and Chibolo bean varieties, the project was unable to obtain any seed at all for those varieties. Such experiences suggest that reaching conservation targets may require several years of building up the genetic resource base, including through purification and multiplication activities. This issue (which may also be viewed as a type of transaction cost) of the importance of access to seeds of threatened varieties is also reflected in the PACS experience in Cotacachi, Ecuador. Unlike Peru, the only rewards requested for conservation activities were access to the seed in question and an appropriate amount of fertilizer. It has also been interesting to note that farmers selected an equal approach to participation, with all farmers asking for the same amount of seeds and fertilizers per unit of land.

5.3) Conditionality, compliance verification and monitoring systems

Conditionality (i.e. the combined sequential effort put into monitoring and sanctioning of non-compliance) is seen as a fundamental conceptual element of PES (Wunder et al., 2018) and plays an important role in the PACS schemes. Conservation service contracts between the conservation project/agency and the participating community groups clearly specify that the agreed in-kind group reward will only be paid at the end of the contract if all members of the group have satisfactorily fulfilled their obligations. Should this not be the case, nobody in the group is rewarded. Such a peer-pressure compliance mechanism is combined with a series of visits during key moments of the agricultural season to the participating communities for compliance verification, monitoring and technical assistance purposes. This has resulted in high compliance rates, with all participants fulfilling their obligations with the exception of one case in 2010. In that particular case, a number of farmers in the group had decided not to plant the threatened quinoa varieties they had contracted to cultivate. Other farmers in the group instead made up for their reduced service provision, thus ensuring that the overall group did not need to be sanctioned.

Post intervention monitoring visits have been less frequent. They are urgently needed to not only inform the varietal focus of subsequent interventions (given that each round of PACS only covers a given proportion of the threatened genetic resources that have been prioritised for conservation), but also to evaluate longer-term effectiveness in the absence of further interventions. As part of its spatial targeting, the PACS selection process purposefully seeks out those farmers with the high preferences for cultivating traditional varieties (as expressed by their bid offers at the lower end of the supply curves). It is therefore perhaps unsurprising that many retain part of their harvest as seed for the following agricultural seasons regardless of whether there will be any further direct incentives to cultivate it. This degree of post-intervention "persistence" is important, as it is a major factor in determining when re-interventions are needed to maintain specific varieties above an "at risk" threshold (within a dynamic systems context) and hence overall conservation programme costs over time.

Evidence from Lavoie et al. (2017) is encouraging. In a visit to Peru (Puno I) communities, persistence rates were shown to be between 30-50% five years after the single year PACS intervention had finished. Furthermore, 83% of farmers declared that they would be willing to participate in further PACS activities, even without receiving rewards, provided they would be given access to the seeds of the threatened varieties.

Unfortunately, few countries in the world, if any, are currently collecting baseline and monitoring data appropriate for indicating when such re-interventions might be required. Such data would also be useful for other ABD management purposes such as pre-intervention prioritization and post-intervention impact assessment. Additionally, such monitoring data would allow the varietal focus of PACS interventions to be refreshed over time, as PACS interventions result in some varieties reaching a "not at risk" status, with others in the conservation portfolio thus moving up the priority list (including in the unlikely event of any leakage/PACS-induced displacement having taken place). Monitoring systems could also be used to allow seed exchange networks to be mapped and supported. Given that the type of data required (variety areas and their spatial distribution, number of farmers, availability and viability of seeds, etc.), such data would have to be collected in a participatory manner (alongside more conventional approaches), thereby generating opportunities to organize and even reward communities for collecting monitoring data that has an important public value (a type of PES for data collection).

5.4) Facilitating Access to Seed

In addition to the challenges of developing the institutional, technical and resource capacities required to implement PACS schemes, a further key challenge during the first few years of intervention is the lack of access to the seeds of the species/varieties that have been identified as a priority for intervention (as they are by definition threatened and rare).

There is thus an urgent need for support for threatened variety seed multiplication, purification, storage and dissemination/exchange. With regard to storage, elsewhere, in similar contexts, community seed banks have been shown (including under the Guatemala ASOCUCH PACS application) to be capable of providing a critical platform around which community-based conservation incentive mechanisms may be developed, while simultaneously addressing the current scarcity of (high public value) traditional species/variety seed and post-harvest storage (Vernooy et al., 2017). PACS rewards may also be used to promote seed sharing (e.g. rewarding farmers who share seed with at least two other farmers).

5.5. Conservation Costs

The PACS schemes have also generated useful cost data with which to undertake "back of the envelope" calculations and inform broader conservation strategy. Modelling of the total and annualised present costs is carried out on the basis of the following factors and assumptions:

- the number of varieties to be conserved
- the percentage of varieties that will need repeated intervention (60%, i.e. a persistence rate of 40%) and the frequency under which such repeat interventions are required (every 5 years) [as per Lavoie et al., 2017]

- the conservation target (five hectares per variety spread across 50-100 farmers) [Bioversity International, 2015]
- the cost per hectare
- monitoring, compliance verification and administration costs (20% of total cost, given that implementation and transaction cost[3] estimates from other PES applications range from 1%-25% and have been shown to be sensitive to the scale of implementation [(MAFF, 2000 pp.96–97; Slangen et al., 2008, pp.204-205])
- a discount rate (5%) and
- an analytical time horizon of 5-50 years (shorter time periods have lower total present costs but spread over fewer years result in higher annualised equivalents).

In Table 1, we noted that average bid offers per hectare were in the range of approximately USD670 to a value of ten times as much. For each priority portfolio of 100 varieties and assuming that the area target for each variety can be achieved with the participation of a sufficient number of farmers at the bottom end of that range, then conservation costs over a 20-year time horizon would amount to just under USD860,000 or USD70,000 p.a. at a 5% discount rate (see Table 2). Of course, if target areas can only be achieved by moving further up the conservation service supply curves and accepting higher average bids, then the costs will be proportionally more.

Table 2: Present Costs for Conserving a 100 Variety Priority Portfolio under a Five Hectare Area per Variety Conservation Target

Average Cost/ha (USD)	670	
Time Horizon (years)	*Total Present Cost (US$)*	*Annualised Present Cost (US$)*
5	382,857	88,430
10	624,057	80,818
20	857,217	68,785
50*	989,877	54,222

#Total Present Cost is the current worth of the (discounted) stream of future costs over the number of years indicated

& Annualised Present Cost is the total present cost expressed as an annuity

*At a persistence rate of 40%, no further interventions are in fact required after year 46. Thus, extending the time horizon further leaves total present costs unchanged, while reducing the annualised present costs to approximately US$50,000 p.a.

While high persistence/low re-intervention rates can help to keep costs down, it is also important to note that the above conservation cost calculations are particularly sensitive to the assumptions regarding such persistence/re-intervention rates, as well as to the number of varieties that require intervention and the size of the conservation target (all of which are likely to be highly context specific). Nonetheless, the annual conservation costs identified above represent only a tiny percentage of the gross production value of even just quinoa in Peru (USD93.4m in 2016, [FAOSTAT]).

[3] Future research to quantify upscaled PACS implementation transaction costs would be useful. The small-scale nature of PACS scheme implementation to date has resulted in fixed support costs that, where documented at all (e.g. Drucker et al., 2015) although small nonetheless represent a high proportion of the total value of the payments. However, these are unlikely to be representative of larger PACS projects where such costs would be expected to fall within the value indicated under this assumption.

5. Conclusions:

The application of PES concepts to the on farm conservation of agrobiodiversity has led to the development of a Payments for Agrobiodiversity Conservation Services (PACS) research and development platform that has been tested and applied on a small-scale across a number of countries and crops in Latin America.

Such experiences suggest that PACS has the potential to play an important role in the implementation of upscaled in situ on farm agrobiodiversity conservation programmes, including as a mechanism for putting Farmers' Rights into practice; and to do so in a cost-effective and socially-equitable way. Farmers may be rewarded not only for their conservation services per se (i.e. cultivation of threatened varieties with high public good values) but also for related services, such as seed sharing and generating monitoring data.

Key messages for those upscaling PACS are that there are indeed a large number of motivated conservation service sellers (i.e. farmers) willing to provide such services at modest cost. Although the compliance rates of those contracted to do so are high, facilitating their access to threatened crop variety seed has been challenging. This has in turn limited (or at least slowed) short-term environmental effectiveness. Systematic monitoring systems are required to determine longer-term environmental effectiveness and orient intervention strategies within a context of changing varietal risk statuses.

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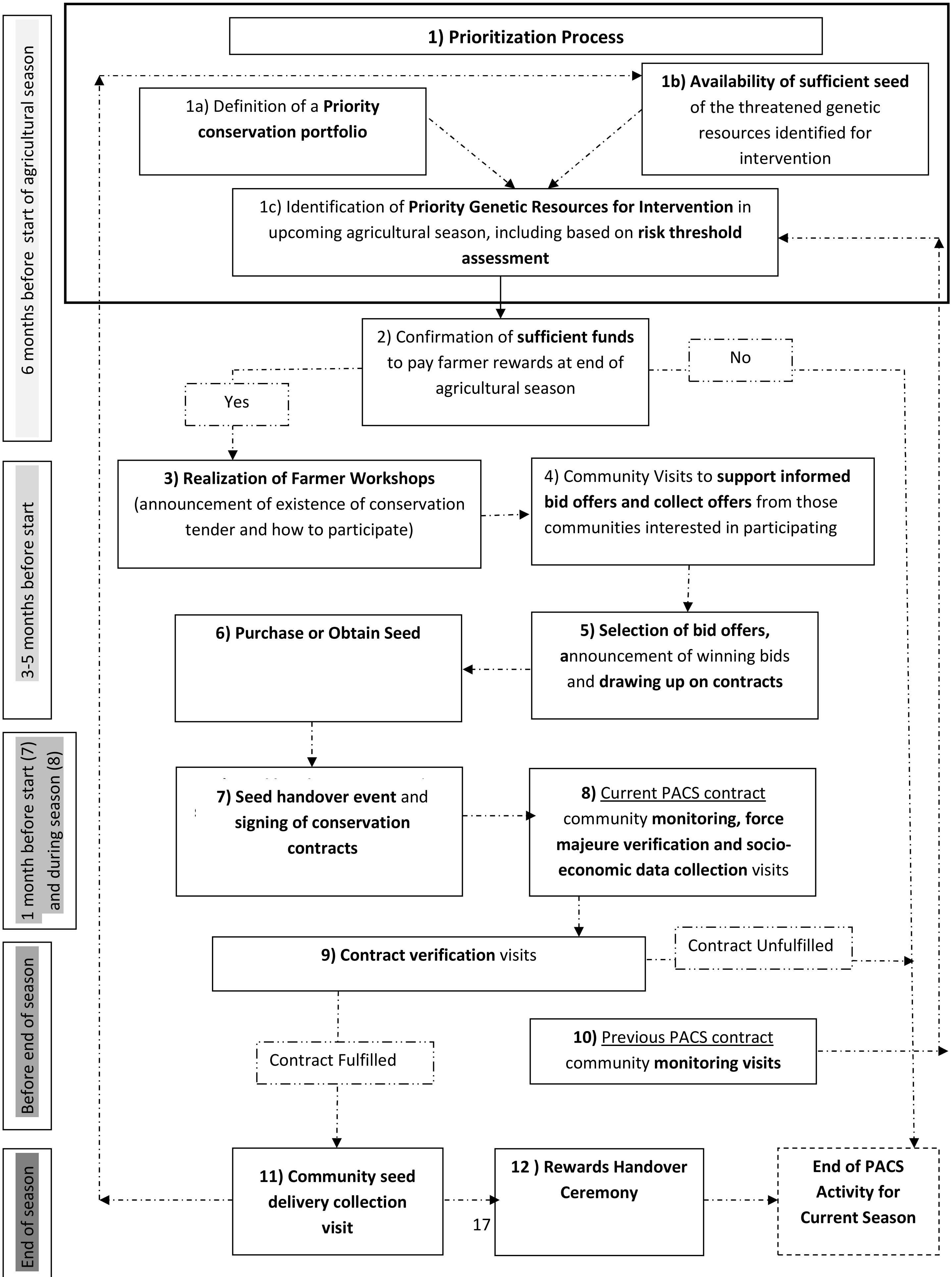

Figure 1: Flowchart of PACS Stages during the Agricultural Season